Optimizing Scientific and Social Attributes of Pharmaceutical Take Back Programs to Improve Public and Environmental Health

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Pharmaceuticals in the Environment: Where do the residues come from?
Accelerating growth:
An opportunity for a comprehensive pilot program

DFW 1987

Population: 3.5 million
Trinity River Flow: 280 cfs

DFW 2005

Population: 5.5 million
Trinity River Flow: >400 cfs

Population in 2050: 11.5-12 million
Pharmaceutical Take-Back Program: Objectives

• Environmental
  – Proper disposal of medications
  – Protection of environmental resources

• Social
  – Prevention of accidental poisoning
  – Prevention of prescription misuse and abuse ("Pharming")

• Product Stewardship
Pharmaceutical Take-Back Program: Gaps

• Quantifiable measures to determine environmental impact of TBP
  – Biomonitoring and chemical monitoring

• Public Risk Perceptions
  – Public understanding and concern about pharmaceuticals in the environment
  – Disposal practices
  – Possible averting behaviors

• Social Marketing Campaigns
  – Sensitive to specific socioeconomics of the community
## Comparing Take Back Programs

### Top 4 Categories of Pharmaceuticals Returned in Safe Medicine Disposal in ME

<table>
<thead>
<tr>
<th>Category of Pharmaceutical</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain/anti-inflammatory</td>
<td>35</td>
</tr>
<tr>
<td>Heart, blood, or cholesterol medicines</td>
<td>34</td>
</tr>
<tr>
<td>Sleep or anti-anxiety medicines</td>
<td>19</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>18</td>
</tr>
</tbody>
</table>

### Categories of Pharmaceuticals Returned in Green Pharmacy Program in Berkeley, CA

<table>
<thead>
<tr>
<th>Category of Pharmaceutical</th>
<th>Percent</th>
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</thead>
<tbody>
<tr>
<td>Central nervous system (CSN)</td>
<td>22.62</td>
</tr>
<tr>
<td>Nutritional products</td>
<td>14.29</td>
</tr>
<tr>
<td>Psychotherapeutic</td>
<td>12.51</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>8.99</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>8.77</td>
</tr>
<tr>
<td>Respiratory</td>
<td>6.00</td>
</tr>
<tr>
<td>Anti-infectives</td>
<td>6.00</td>
</tr>
<tr>
<td>Alternative medicines</td>
<td>5.69</td>
</tr>
<tr>
<td>Hormones</td>
<td>4.60</td>
</tr>
<tr>
<td>Immunologic</td>
<td>2.85</td>
</tr>
</tbody>
</table>

## Pharmaceutical Take-Back Program: Measures of Success

<table>
<thead>
<tr>
<th>Standard</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of medications collected</td>
<td>Improved public risk perception and/or community image</td>
</tr>
<tr>
<td>Participation rates</td>
<td>• Behavioral modification</td>
</tr>
<tr>
<td>Measures of success often overlooked or not</td>
<td>Scientific justification</td>
</tr>
<tr>
<td>defined clearly in TBP planning</td>
<td>• Computer modeling &amp; biological and chemical monitoring of water quality</td>
</tr>
<tr>
<td></td>
<td>before and after TBP event</td>
</tr>
</tbody>
</table>
Current Road Blocks to a Pharmaceutical Take-Back Program

• Legal road blocks
  – Controlled Substance Act (CSA) administered by Drug Enforcement Agency (DEA)
    • Narcotics, Valium, amphetamines, Ritalin, morphine, methadone, oxycodone
  – Law enforcement officers present or deputize select TBP organizers if possible

• Cost
  – Disposal services
  – Advertising/social marketing
  – General staffing
  – Law enforcement agents
  – Pharmacists
  – Science

• Public awareness and support
  – Education and risk communication through social marketing campaign
H.R. Bill 276:
The Drug Free Water Act

• Bill currently being considered in the House
  ◦ “Prevent or reduce the detrimental effects caused by introducing such materials [pharmaceuticals] into water systems and for limiting the disposal of unused pharmaceuticals through treatment works”
  ◦ Establish an EPA task force for developing recommendations for proper medicine disposal
  ◦ Develop a public education strategy
A New Approach

Project Purpose

- Develop a decision-making framework for an optimized TBP paradigm
- Include scientific and social attributes
- Sustainable solution to the public and environmental health threat of pharmaceuticals
Hypothesis

Following the implementation of an optimized TBP, there will be no change in:

- Public health, as measured by accidental drug poisonings; or
- Environmental health, as measured by the concentrations of representative drugs in WWTP effluent.
Objective 1

- Develop effective methodologies to communicate the public and environmental health risks associated with unused pharmaceuticals.
  - Surveys 1 & 2 to understand public’s perception, disposal practices and 1st take back event participation
  - Educational tools to increase public awareness and participation for the second TBP
  - Survey 3 to evaluate success of education strategies
Objective 2: Determine public health benefits of TBPs

- Calculate class-specific mass of drugs returned during the TBPs and determine if the TBP was effective in reducing human drug poisonings when compared to data prior to the first TBP.
Objective 3: Determine Pharmaceutical loading to WWTP as a measure of environmental health

- Measure ibuprofen and diazepam concentrations in WWTP influent and effluent
- Calculate theoretical loadings of ibuprofen and diazepam to the environment and using the mass of these drugs returned in the TBP determine the theoretical difference in loading.
Anticipated Results

- Develop decision-making framework for an optimized TBP to address gaps in standard TBP model:
  - Incorporate public awareness and risk perception through an education campaign
  - Scientific justification
- Model for future TBPs
- Demonstrate TBP can be a sustainable and proactive strategy for:
  - Promoting waste reduction
  - Addressing public and environmental health threats
Why this is important to the City of Denton
Wastewater in Denton

Plant is permitted at 21 MGD
Average discharge ~13 MGD
Looming Issue: Drugs in Waters

- Not present at therapeutic doses
- Potential adverse impacts:
  - Water quality issues
    - WWTP Effluent
    - Drinking Water?
  - Endocrine disruption (physical, mental, sexual development)
  - Antibiotic resistance
  - Public perception
Endocrine Disruption

- Endocrine system regulates hormones in the body
- Endocrine disruptors interfere with this system
- Affect reproduction, development, and behavior
- Disruption even at very small concentrations
- Multigenerational effects (DES at therapeutic doses)
- No current evidence of human impacts at low concentrations
Wastewater Process Considerations

- BOD removal
- Suspended solids removal
- pH neutralization
- N, P removal
- Pathogen removal
- **Processes for removal of pharmaceuticals are not typical**
Pecan Creek: An Effluent-dominated Stream
Denton County, TX

- Vitelligenin (and egg precursor) production and other indicators or possible feminization in male fish – Jon Hemming
- Beta adrenergic heart medicines and steroids (Duane Huggett)
- Fluoxetine (Prozac) and Sertraline (Zoloft) in Fish Tissue (Bryan Brooks)
- Fluoxetine and Sertraline in tissues of periphyton and benthic macroinvertebrates – (Bryan Brooks)
- Antimicrobials (Triclosan, etc) in algal and snail tissues – Melinda Coogan
- Illicit Drugs in WWTP influent and Effluent (Duane Huggett)